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September 29, 2004

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APPLICATION NUMBER: ***60/500,041***
FILING DATE: ***September 04, 2003***
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Certified by

Jon W Dudas

Acting Under Secretary of Commerce
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Patent and Trademark Office

PTO/SB/16 (08-03)

PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

Express Mail Label No.	EV 321 687 971 US

INVENTOR(S)

Given Name (first and middle [if any])	Family Name or Surname	Residence (City and either State or Foreign Country)
Danny Phil	BLANCHARD LIGRANI	Salt Lake City, Utah Salt Lake City, Utah

Additional inventors are being named on the 1 *separately numbered sheets attached hereto*

TITLE OF THE INVENTION (500 characters max)

VISCOUS MICROPUMP

Direct all correspondence to: CORRESPONDENCE ADDRESS

☐ Customer Number: 27478

OR

☐ Firm or Individual Name					
Address					
Address					
City		State		ZIP	
Country		Telephone		Fax	

ENCLOSED APPLICATION PARTS (*check all that apply*)

☒ Specification *Number of Pages* 11

☒ Drawing(s) *Number of Sheets* 4

☐ Application Date Sheet. See 37 CFR 1.76

☐ CD(s), Number

☐ Other (specify)

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT

☒ Applicant claims small entity status. See 37 CFR 1.27.

☒ A check or money order is enclosed to cover the filing fees.

☒ The Director is hereby authorized to charge filing fees or credit any overpayment to Deposit Account Number: 50-0581

☐ Payment by credit card. Form PTO-2038 is attached.

FILING FEE Amount ($): $80.00

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

☒ No.

☐ Yes, the name of the U.S. Government agency and the Government contract number are:

Respectfully submitted,

SIGNATURE James L. Sonntag

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Date September 4, 2003

REGISTRATION NO. 30,224
(if appropriate)

Docket Number: U3550P.2

USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

263980.1

09/04/03 17114 U.S. PTO

19587 U.S. PTO 60/500041 09/04/03

PROVISIONAL APPLICATION COVER SHEET
Additional Page

PTO/SB/16 (08/03)

Docket Number	U3550P.1

INVENTOR(S)/APPLICANT(S)

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Bruce	GALE	Salt Lake City, Utah

Number 2 of 2

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263980.1

EXPRESS MAIL LABEL NO. EV 321 687 971 US
SEPTEMBER 4, 2003

United States Provisional Patent Application

Title: VISCOUS MICROPUMP

Attorney Docket Number: U3550P.2

Inventors:

Danny Blanchard, Salt Lake City, Utah

Phil Ligrani, Salt Lake City, Utah

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Title

VISCOUS MICROPUMP

Cross Reference to Related Applications

[0001] (Not applicable)

Federal Research Statement

[0002] (Not applicable)

Background of Invention

[0003] There is a need for simple micropumps that can deliver a variety of flow rates and pressures. The micropump of the invention is an ideal solution because it is easy to make, is reliable, and the flow rate and pressure rise can be adjusted by changing the operating speed, and fluid channels dimensions.

Summary of Invention

[0004] The micropump of the invention uses the viscous properties of a fluid to produce a pumping effect. The pump consists of at least one spinning disk and a wiper. The wiper is positioned on the spinning surface of the disk. The disk is connected to a motor. Viscous forces cause the fluid to follow the movement of the spinning disk or disks. The wiper is used to "wipe" the fluid from the disk and direct the fluid to the outlet channel.

[0005] The pump comprises one or more disks. In an embodiment with two spinning disks the wiper is positioned between the two disks. The disks can be spun individually or coupled together with a connector shaft.

[0006] An aspect of the invention is a micropump comprising at least one disk with a disk surface spinnable about an axis orthogonal to the surface, and a wiper with wiper surface over a portion of the disk surface. An inlet channel directs fluid to the disk surface. Fluid from the inlet flows over the spinning disk surface such that momentum is transferred to the fluid from the disk. The wiper is placed with

the wiper surface over a portion of the disk surface and near or on the disk surface. This is to direct a substantial portion of the fluid from the spinning disk surface toward an outlet channel.

[0007] There can be one disk with one disk surface, double sided disks, or multiple disks with respective disk surfaces. One embodiment of the invention comprises a single disk with single wiper, as further described below. Another embodiment comprises two disks with respective facing and parallel disk surfaces, with a double sided wiper in between, which is also further described below.

[0008] The viscous micropump of the invention could be used in various applications where a micropump is required. Such applications include, but not limited to, electronics cooling, implantable medical devices, μ-TAS (micro Total Analysis Systems), and fluid dispensing systems.

[0009] The viscous micropump of the invention has no small parts that can break (like valves, small structures, or microblades). The micropump is also simple to make, which could produce low cost manufacturing. The micropump also supplies a continuous flow rate (not pulsating like single membrane micropumps).

Brief Description of Drawings

[0010] FIG. 1A is schematic of a single disk viscous micropump of the invention showing a three-dimensional representation of the configuration of the fluid flow channel, and the wiper and their relationship to the disk.

[0011] FIG. 1B is a schematic cross-section of the single disk micropump.

[0012] FIG. 2A and FIG. 2B are schematic diagrams showing wipers with straight and curved channel constructions, respectively.

[0013] FIG. 3A is a schematic of a double disk viscous micropump of the invention showing a three-dimensional representation of the configuration of the fluid flow channel, and the wiper and their relationship to the two disks.

[0014] FIG. 3B is a schematic cross-section of a double disk micropump.

[0015] FIG. 4 is a graph of the flow rate vs. rpm for the double disk viscous pump with a wiper height of 0.004 inches and disk diameter of 3/32 inches.

Detailed Description

Single Disk Viscous Micropump

[0016] Fig. 1A and FIG. 1B shows an example of a single disk viscous micropump of the invention. Shown in FIG. 1A is a 3-D model showing the channels for fluid flow, the wiper and their relationship to the disk. In FIG. 1B is a cross-section of the single disk viscous micropump.

[0017] The micropump comprises a spinning disk and a wiper, which is preferably formed by the channel walls. The top of the channel is stationary. The disk provides a flat surface that is spun with a motor, with the surface being spun in a plane orthogonal to the axis of rotation. The disk can be provided by a top surface of a shaft or cylinder, as illustrated, or any other suitable shape that provides a flat surface that can be spun with a motor, such as a flat platter.

[0018] The wiper is formed by the channel walls. This is done by manufacturing the channel integrally with the wiper or by inserting a separate wiper part into a channel. The wiper is fixed in placed and disposed with a wiping surface adjacent to or touching a portion of the spinning disk surface. Fluid enters the micropump through the inlet channel. When the fluid in the channel is above the disk it follows the motion of the spinning disk due to the no-slip condition at the disk surface, and the diffusion of momentum in the fluid. When the fluid reaches the wiper, the fluid can no longer follow the surface of the disk, because the wiper is contacting, or nearly contacting the surface of the disk. The fluid at the wiper is then pushed toward the outlet channel by the following fluid. The continuous spinning of the disk produces a constant flow of fluid from the inlet to the outlet.

[0019] The wiper contacts or nearly contacts the surface of the disk. This is to inhibit flow of fluid between the wiper surface and disk surface and instead push it from

the disk surface and have it flow toward the outlet channel. The distance between the disk surface and the wiper surface should be such that only a minor portion of the fluid continues to follow the disk surface under the wiper, and depends, among other factors, the requirements for the micropump, and the properties of the fluid and pump materials.

[0020] The surface of the disk should be of a material that is compatible with the fluid such that it transfers momentum to the fluid as described above. The material of the wiper surface should also have compatible properties. For water, a polished metal surface, such as steel or brass, is suitable for wiper and disk surfaces. The wiper and disk surfaces may optionally be coated or textured to increase the drag between the fluid and the surface. In general the surface is generally flat, but the present invention contemplates a disk surface (and matching wiper surface) with non-linear irregularities, such as grooves, along its radius, or a rounded or dished disk surface (and matching wiper surface). The requirement is that the spacing between the wiper surface and the disk surface be maintained within a functional range.

[0021] Any placement and configuration of the wiper that functions as described is contemplated. A preferred wiper system is where the wiper extends from or near the center axis of the disk to a segment of the circumference. In FIG. 1A, the point of the wiper is in the center of the disk. This point could also be rounded, and/or placed further from the center. The relationship between the inlet and outlet channels may be any suitable construction. In FIG. 1A, the inlet and outlet channels in Fig. 1 form a right angle. Alternately, the angle of inlet and outlet channels can be varied to form a straight channel (FIG. 2A), or form an angle less than 90 degrees (FIG. 2B).

Fabrication

[0022] The single disk viscous micropump can be fabricated using a variety of techniques. These techniques include surface micro-machining, bulk micro-machining, and precision machining. The particular micropump used in the tests

was made using precision machining techniques. The bottom of the channels, as well as the bearing is made from Torlon^{TM}. The top of the channels is made from Plexiglass^{TM}. The channel walls, and the wiper is precision machined from brass shim-stock. The disk is a stainless steel shaft with a polished end. The diameter of the disk is 3/32 inches.

[0023] In general, the dimensions depend upon several factors, including, but not limited to the properties of the fluid, and the flow requirements. The materials used for the micropump can be any suitable material, and may be molded machined, or manufactured by any suitable technique.

Double Disk Viscous Micropump

[0024] The double disk viscous micropump is constructed using the same principles as used in the single disk viscous pump. A difference is that there are two disks and two wiper surfaces, one for each disk. This is accomplished with one wiper disposed between two disks with facing surfaces.

[0025] FIG. 3A shows a 3-D model of an example of a double disk viscous micropump embodiment of the invention. The micropump comprises two spinning disks and a single wiper formed by the channel walls. The two disks can be powered by two separate shafts (one coming from the bottom, and one from the top, or telescoping shafts), or can be coupled together with a connector shaft. FIG. 3B shows two disks coupled together with a connector shaft. In this embodiment there are two disks, a top disk and the bottom disk, with the wiper disposed between the disks.

[0026] The orientation of the channels and considerations for the wiper are the same as for the above single wiper embodiment. The inlet and outlet channels can form a right angle as in FIG. 3A, or be varied as shown in FIG. 2A (straight) or FIG. 2B (acute angle).

Fabrication

[0027] The double disk viscous micropump can be fabricated using a variety of techniques, similar to those used for the single disk viscous micropump. These techniques include surface micro-machining, bulk micro-machining, and precision machining.

[0028] The micropump for the tests below was made using precision machining techniques. The bottom and top of the channels, as well as the bearing is made from Torlon™. The channel walls and the wiper are precision machined from brass shim-stock. The disk is a yellow brass shaft with a polished end. The diameter of the disks is 3/32 inches. There are a variety of other materials that can be used to make this single disk viscous micropump.

Test

[0029] Initial testing has shown that the double disk viscous micropump pumps DI water at flow rate of about 2.0 ml/min, spinning at 5000 rpm, with a 0.004 inch wiper height. Fig. 4 shows a plot of the initial testing of the double disk viscous micropump.

Commercial Market

[0030] There is a need for simple micropumps that can deliver a variety of flow rates and pressures. As shown by the exemplary single and double disk viscous micropumps, a micropump of the invention can be made that is an ideal solution, because it is easy to make, is reliable, and the flow rate and pressure rise can be adjusted by changing the channel height, and operating speed.

[0031] While this invention has been described with reference to certain specific embodiments and examples, it will be recognized by those skilled in the art that many variations are possible without departing from the scope and spirit of this invention, and that the invention, as described by the claims, is intended to cover all changes and modifications of the invention which do not depart from the spirit of the invention. Variation of the present invention include, but are not limited to,

micropumps with two wipers and a single platter with two disk surfaces, or micropumps with several ganged disk surfaces, using appropriate multiple wipers, either with single or dual wiper surfaces, or a wiper that contacts, or nearly contacts, the flat surface and continues down the outer diameter of the spinning disk. The multiple disk surfaces may be spun together with a connector shaft driven by a motor or by separate shafts with common or separate motor or drive systems.

Claims

What is claimed is:

1. A micropump comprising;

at least one disk with a disk surface spinnable about an axis orthogonal to the surface,

wiper with wiper surface,

an inlet channel to direct fluid to the disk surface, such that fluid from the inlet flows over the spinning disk surface and such that momentum is transferred to the fluid from the disk,

an outlet channel,

the wiper placed with the wiper surface over a portion of the disk surface and near or on the disk surface to direct a substantial portion of the fluid from the disk surface toward the outlet channel.

2. The micropump of Claim 1 wherein the portion over which the wiper surface extends is from a point near the axis of the disk to a portion of a circumference of the disk surface.

3. The micropump of Claim 1 wherein the inlet channel and the outlet channel are disposed to;

together form a straight channel, or

meet at a right-angle, or

meet at an acute angle.

4. The micropump of Claim 1 wherein the shape of the wiper near the center of the disk is pointed or rounded.

5. A micropump comprising;

a single disk with a single disk surface spinnable about an axis orthogonal to the surface,

single wiper with a wiper surface

an inlet channel to direct fluid to the disk surface, such that fluid from the inlet flows over the spinning disk surface such that momentum is transferred to the fluid from the disk,

an outlet channel

the wiper placed with the wiper surface over a portion of the disk surface, with each wiper surface near or on the disk surface so as to direct a substantial portion of the fluid from the disk surface toward the outlet channel.

6. A micropump comprising;

upper and lower disks with parallel upper and lower disk surfaces facing each other and both spinnable about an axis orthogonal to the surfaces,

single wiper with an upper and a lower wiper surface

an inlet channel to direct fluid to the disk surface, such that fluid from the inlet flows over the upper and lower spinning disk surfaces such that momentum is transferred to the fluid from the disk,

an outlet channel

the wiper placed with the lower wiper surface over a portion of the lower disk surface and the upper wiper surface over a portion of the upper disk surface, with each wiper surface near or on the respective disk surfaces so as to direct a substantial portion of the fluid from the respective disk surfaces toward the outlet channel.

Abstract of Disclosure

[0032] A viscous micropump is disclosed that uses a spinning disk surface to transfer momentum to the fluid being pumped by allowing fluid from an inlet channel to follow the disk surface as it spins. A wiper surface over a portion of the disk surface directs the fluid from the spinning disk and toward an outlet.

FIG. 1A

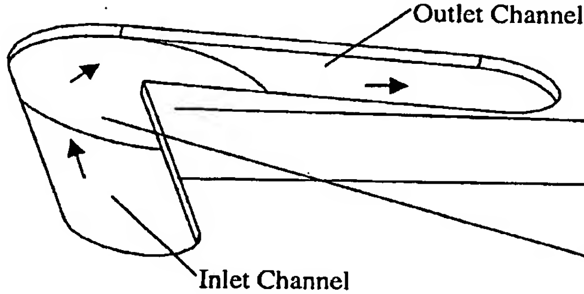
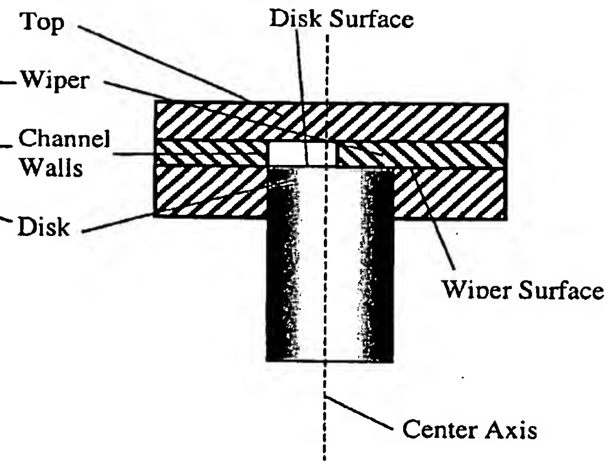

Outlet Channel
Inlet Channel

FIG. 1B


Top
Wiper
Channel
Walls
Disk
Disk Surface
Wiper Surface
Center Axis

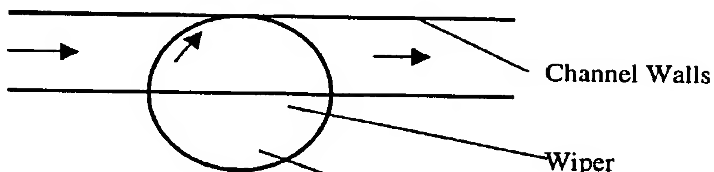

Channel Walls
Wiper
Disk Surface

FIG. 2A

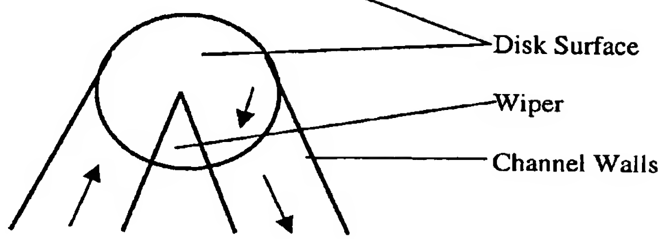

Disk Surface
Wiper
Channel Walls

FIG. 2B

FIG. 3A

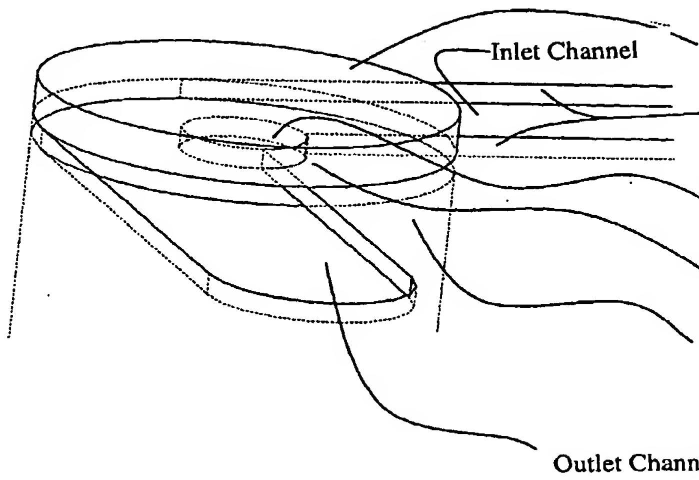

Inlet Channel
Outlet Channel

FIG. 3B

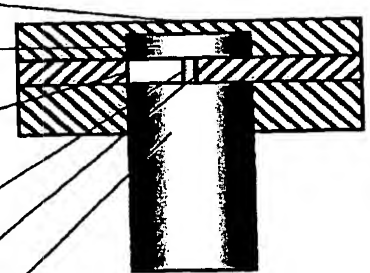
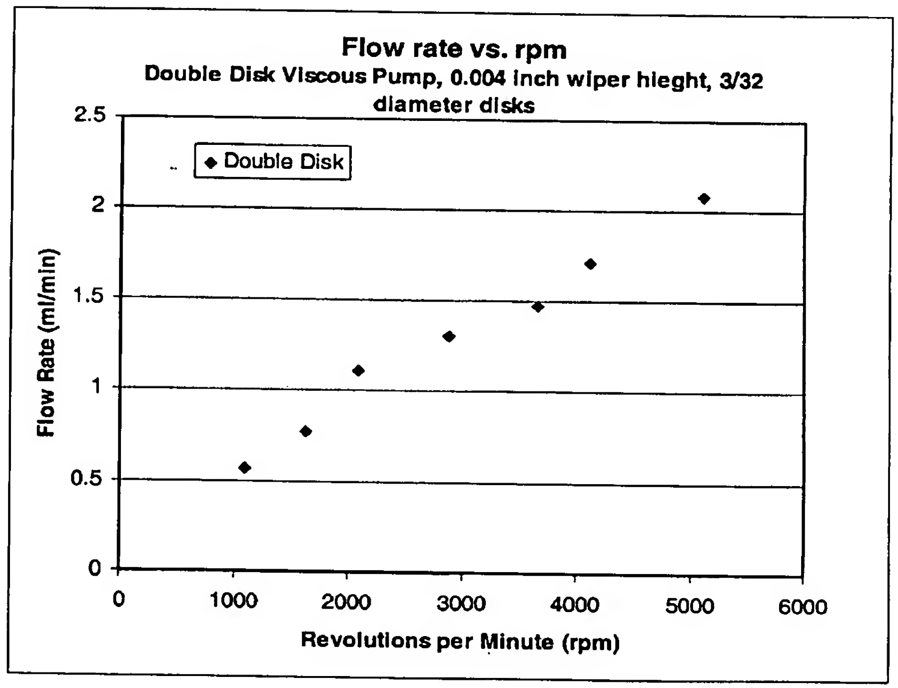

Top
Top Disk
Channel Walls
Coupling Shaft
Wiper
Bottom Disk

FIG. 4


Flow rate vs. rpm
Double Disk Viscous Pump, 0.004 inch wiper hieght, 3/32 diameter disks
Double Disk
Flow Rate (ml/min)
2.5
2
1.5
1
0.5
0
0
1000
2000
3000
4000
5000
6000
Revolutions per Minute (rpm)